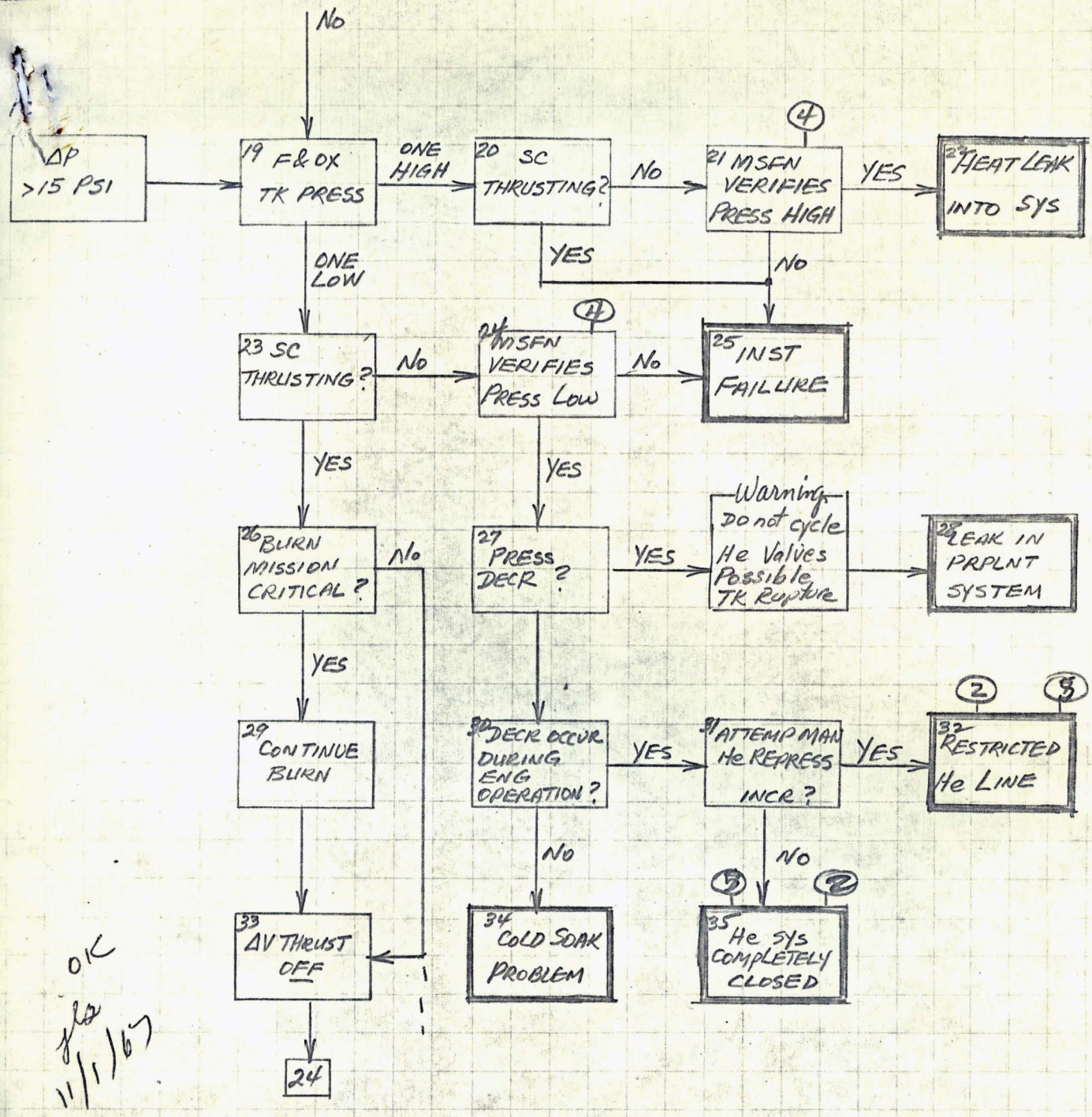
10-6-1967

Service Propulsion System (SPS) - Malfunction Symptoms 1 - 10 hand drawn diagrams

National Aeronatics and Space Administration (NASA)

SPS



OK
gla
11/1/67

(4) CAUTION - ΔP between F & OX TK-PRESS should not exceed 15 PSI during a burn. Degraded performance, rough combustion, and/or engine failure may result.

(2) System operable until SPS Pc is <TBD psia. Engine chugging may occur.

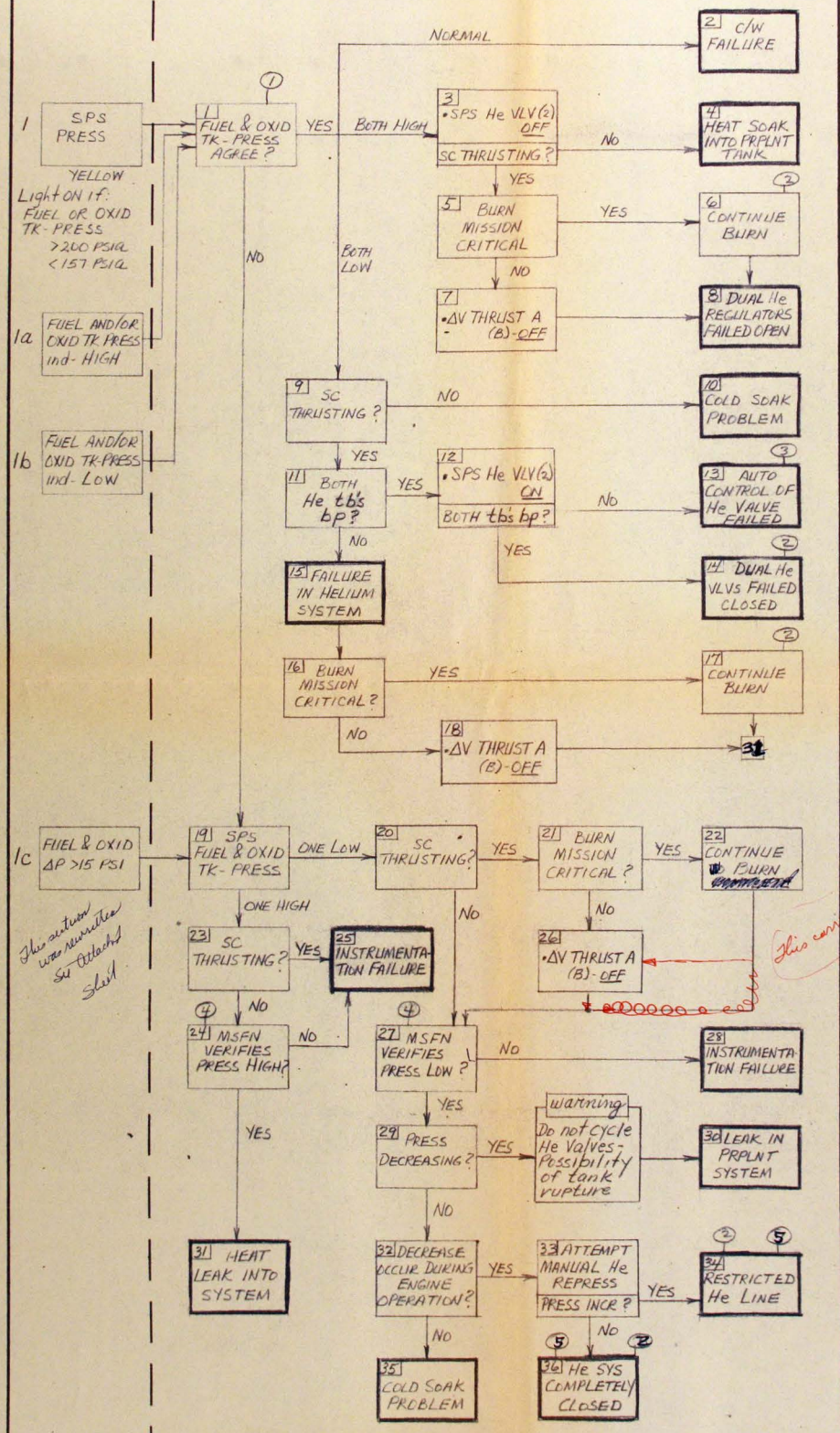
(7) All subsequent SPS burns should be made with SPS He VLVs OFF to minimize ΔP between F & OX.

(8) System operable until SPS, PC, or engine indication requires shutdown.

ACTION ITEMS LAST PAGE 11/1/67

procedures 11/3/67 reviewed no changes

SYMPTOM | PROCEDURE | REMARKS



This section was rewritten See Attached Sheet

This correction was not made on the review of 10/30/67 but it needs to be so 11/1/67

1. Normal operating pressure is 170-195 Psia. MSFN will use FUEL & OXID telemetered pressure data to backup onboard indications.

2. System operable until SPS Pc is < TBD Psia. Engine chugging may occur

3. Manual He Valve control required

4. CAUTION - ΔP between FUEL & OXID TK-PRESS should not exceed 15 PSI during a burn. Degraded performance, rough combustion, and/or engine failure may result.

5. All subsequent SPS burns should be made with SPS He VLV (2) - OFF to minimize ΔP between FUEL & OXID.

6. System operable until SPS Pc reaches TBD or engine indication requires SHUTDOWN

G&N MALFUNCTION
SCS MALFUNCTION
SPS MALFUNCTION
RCS MALFUNCTION
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T/C MALFUNCTION
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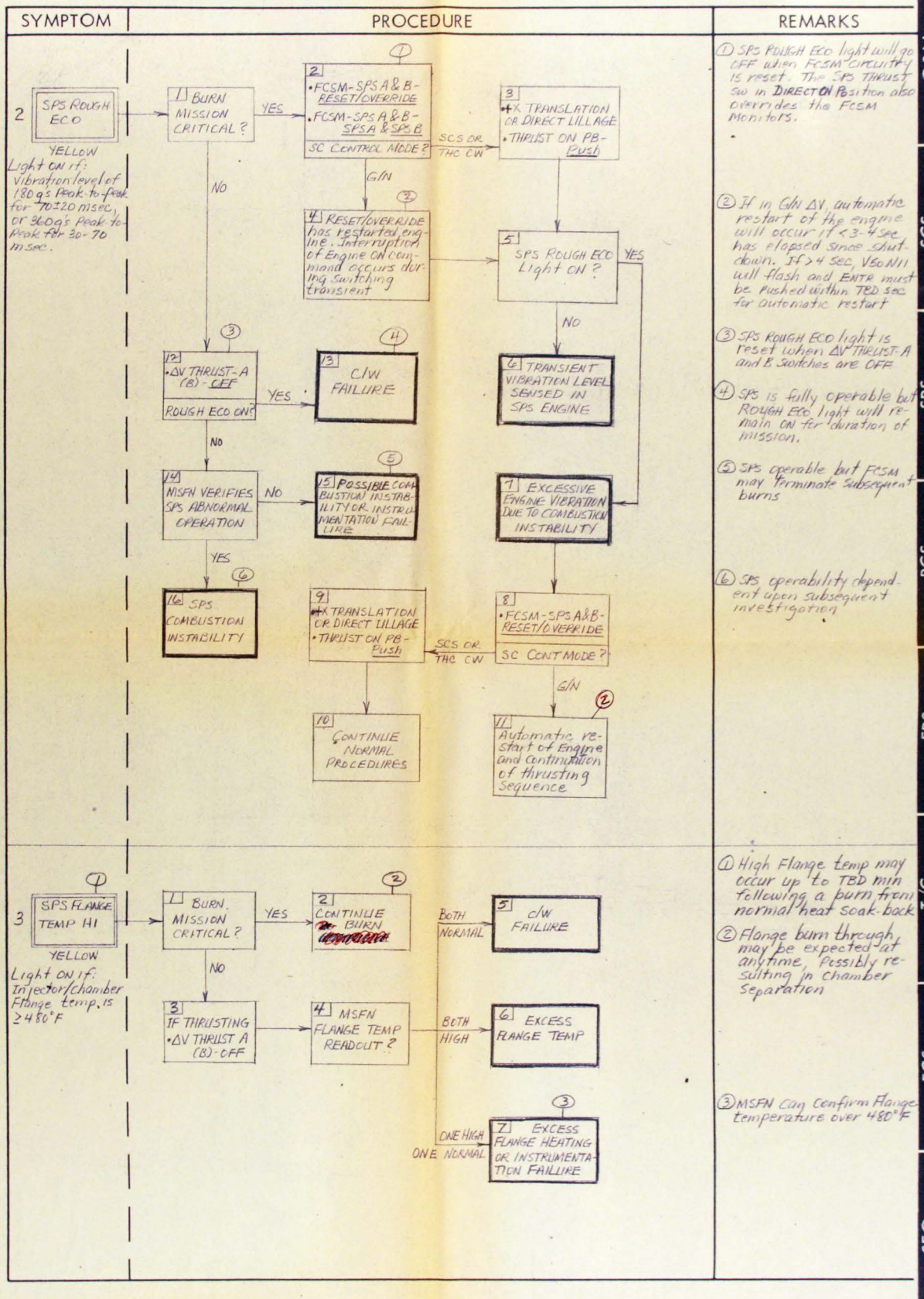
SEQ MALFUNCTION

Basic Date _____ Change Date _____ Page _____



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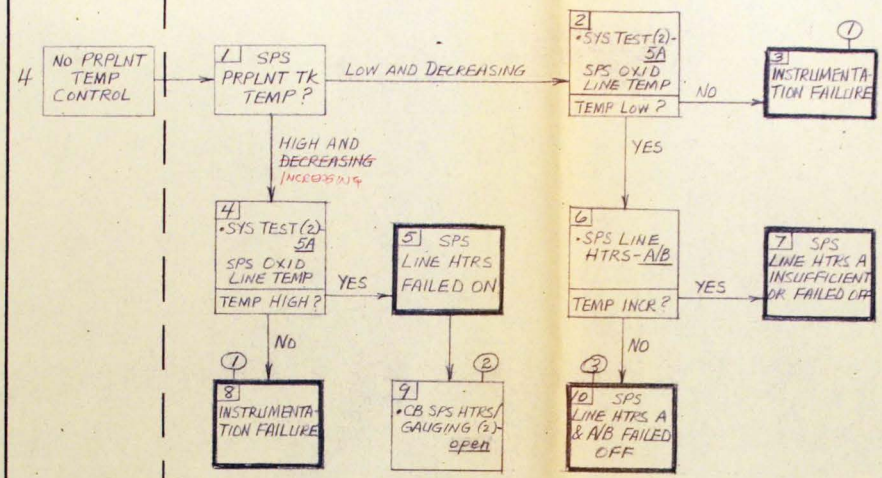
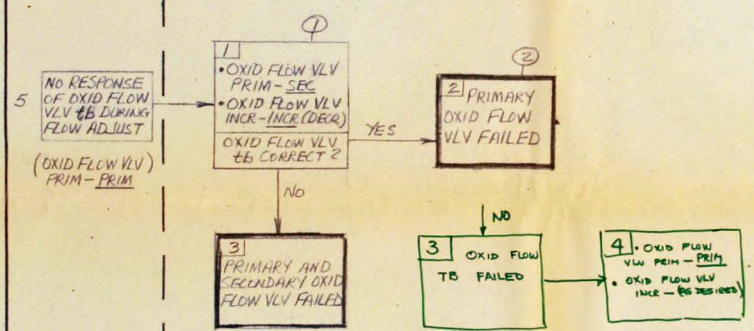
SYMPTOM	PROCEDURE	REMARKS



(1) Use OXID line temp for SPS PRPLNT temp

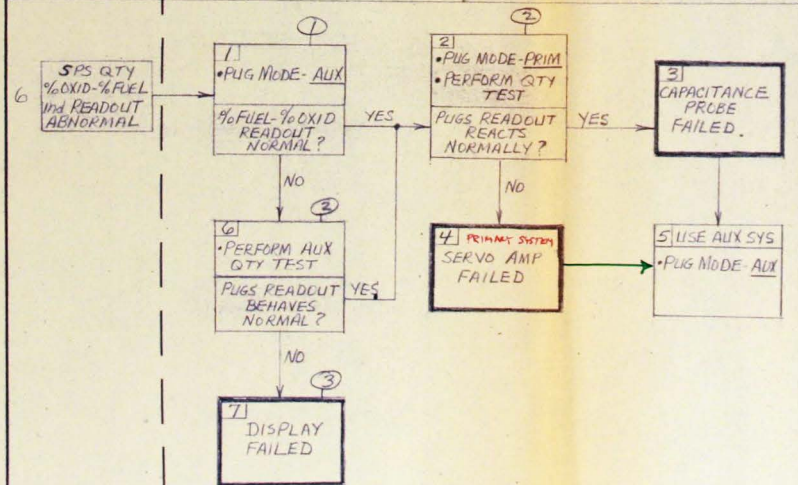
(2) SPS HTRS/GAUGING Circuit Breakers should be closed before SPS Engine operation

(3) Propellant temp may be increased by SC orientation or by firing SPS Engine



(1) Switch position as required to adjust desired flow rate. Valve cannot be operated unless power is applied through THRUST ON signal or through SPS QTY TEST sw. If flow valve position was changed by SPS QTY TEST sw, Fuel and Oxid quantity readouts must be returned to original values

(2) Secondary valve has sufficient range to compensate for primary valve failure in any position and still provide valve openings for INCR, NORM or DECR oxid flow



(1) Assumes SC is still thrusting. If thrusting terminated before step [1] is Complete, proceed to step [6].

(2) Complete thrusting prior to QTY TEST
~~(SPS TEST TOOLS NOTED AT LATER DATE)~~
below checklist

(3) MSFN must now supply any Propellant quantity data

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SYMPTOM	PROCEDURE	REMARKS
7 SPS QTY OXID UNBAL Ind ERRATIC OR PEGGED	1 • PLUG MODE - AUX; OXID UNBAL Ind NORMAL? YES → 2 PRIMARY UNBALANCE SYSTEM FAILED; NO → 3 • PERFORM AUX QTY TEST; OXID UNBAL Ind NORMAL? YES → 4 PRIMARY ~~AUX~~ ~~SENSING~~ UNBALANCE SYSTEM FAILED; NO → 5 ~~SERVICE THAT~~ ~~OXID~~ OXID UNBAL Ind FAILED → Return to Norm PLUG MODE • PLUG MODE - PRIM • Perform Prim Qty test • PLUG MODE - NORM	⓪ ~~Assume SC is thrusting and monitor system during~~ Sensing system failures shown by (print & auto) unused down-ing and be handled in procedure to ① Assumes SC is still thrusting. If thrust has terminated proceed with step 2. ② If thrusting terminated before step 1 was completed, the AUX Sensing system can be checked during the next SPS burn ③ actuation of SPS QTY TEST switch will realign digital display to Primary system.
8 HELIUM TANK PRESSURE LOW OR DECREASING	1 MSFN VERIFIES SPS He TANK PRESS LOW OR DECREASING? YES → 2 LEAK IN HELIUM SUPPLY; 3 HELIUM INSTRUMENTATION FAILURE; No → 3	① MSFN will monitor redundant Helium Pressure instrumentation ② Helium depletion imminent ③ SPS Engine operable until Pc reaches TBD or until Engine indications require shutdown
9 SPS He VLV tb ABNORMAL	1 SC THRUSTING? YES → 2 • SPS He VLV 1(2) - ON; tb's gray? YES → 6 He AUTO MODE MALFUNCTION; No → 3 SPS FUEL & OXID PRESS DECREASING → 4 BOTH He VLVS FAILED CLOSED; STEADY → 7 tb or ONE He VLV FAILURE; NO → 5 • SPS He VLV 1(2) - OFF; tb's bp? YES → 6; NO → 7	① SPS Engine operable until Pc reaches TBD or until Engine indications require shutdown

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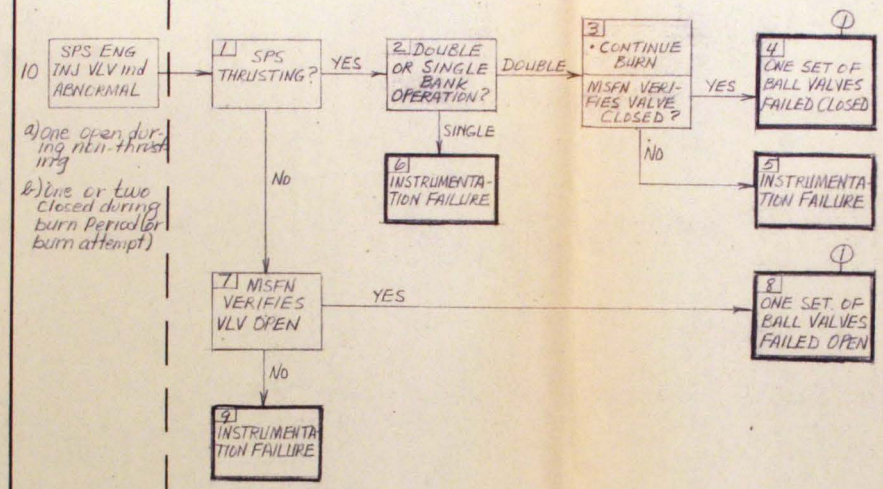
SYMPTOM	PROCEDURE	REMARKS
10 SPS ENG INJ VLV ind ABNORMAL a) One open during nttn-thrust intg b) One or two closed during burn Period (or burn attempt)		① SPS fully operable on redundant bank if one bank failed

gfs 11/1/67

Action Items

① Proc 1 Remark ② Pc TBD

② Decision should be made in [illegible] whether to use "Direct ON" for [illegible] next burn

③ Proc 3 – [illegible] Remark ① [illegible] TBD

Proc 6 ⑤ [illegible] Remark ③ Pc TBD

9 ② [illegible] Pc TBD

④ Proc 6 Entry test to be added (on check list)

⑤ Symptoms to be added:
a) Eng Shuts down prematurely
b) Abnormal Eng Thrust

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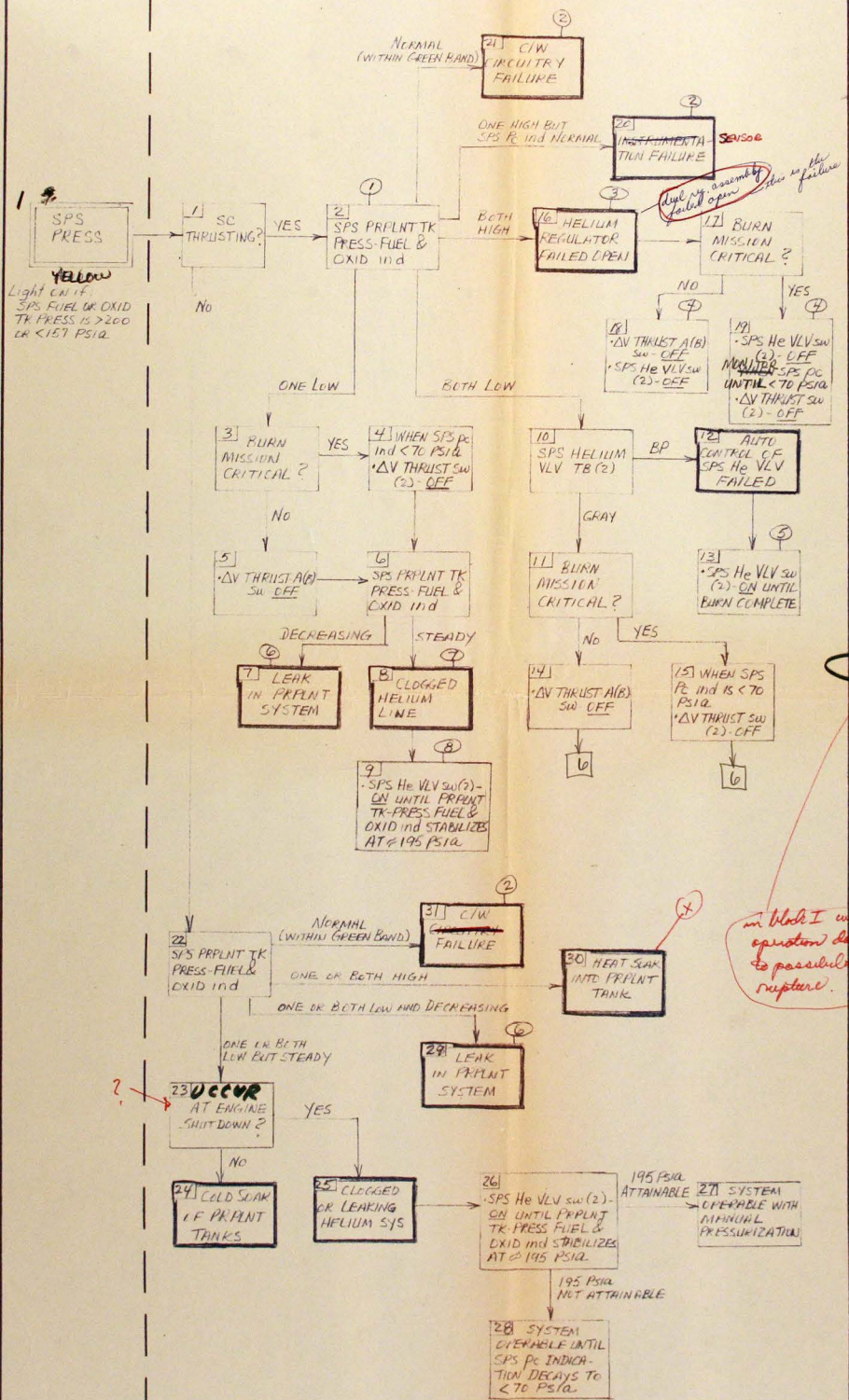
ADMIN - 167 Expires 9-15-67

SPS — 11/1/67

NAA 1st Cut 3-0-66

SYMPTOM	PROCEDURE	REMARKS



(1) Normal operating Pressure is 170-195 PSIA. MSFN will use FUEL and OXID telemetered Pressure data to backup onboard Pressure indication

(2) SPS fully operable.

(3) SPS Helium Valve Switches must remain OFF for duration of mission.

(4) If ΔV THRUST SWITCHES - OFF Prior to SPS pc indication of < 70 PSIA, more burns may be accomplished, but SPS He VLV Switches must remain OFF - ΔV THRUST sw switches - OFF when SPS pc indication decays to < 70 PSIA

Block I stated there was 20 sec of engine fire from when prop lighter he valves closed off

(5) SPS operable with manual Pressurization during burns.

(6) Further operation of SPS may be highly hazardous due to possibility of Propellant leakage.

(7) SPS operable per step 9

Bad note

(8) Manually repressurize Prior to each burn.

(X) Burst disk ruptures at 219 Relief valve opens at 232 reseats at 208

in block I we could further operation dangerous due to possibility of a tank rupture.

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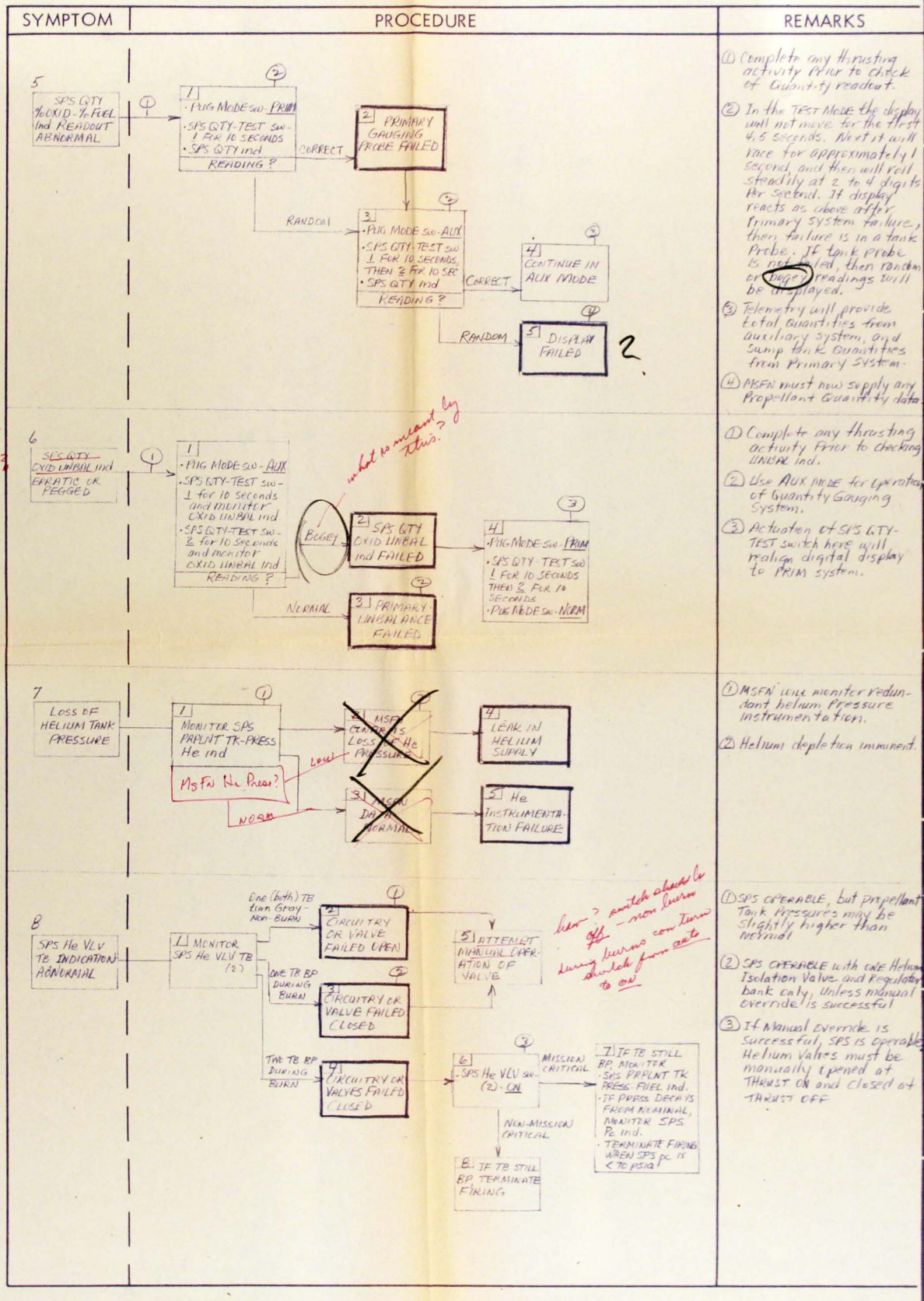
SPS - 1 copy



ADMIN - 167 Expires 9-15-67

SYMPTOM	PROCEDURE	REMARKS
1 SPS FLANGE TEMP HI (YELLOW)	1 BURN MISSION CRITICAL? YES → 2 CONTINUE BURN; No → 3 IF THRUSTING • ΔV THRUST-A (B) SW - OFF → 4 EXCESS FLANGE HEATING OR INSTRUMENTATION FAILURE	(1) Flange burn through may be expected at anytime, possibly resulting in chamber separation. Maximum temperature should occur after shut down. (2) MSFN can confirm flange temperature over 480°F. Loss of entire chamber very possible upon re-firing of SPS.
2 PRPLNT HTRS FAIL TO RAISE PRPLNT TEMPERATURE	1 • SPS-LINE HTRS sw A/B • SPS PRPLNT TK-TEMP ind; TEMP INCREASES? YES → 2 SYSTEM A HEATING INSUFFICIENT OR FAILED OFF; No → 3 DUAL HTRS SYS FAILED. SWITCH, OR INSTR-UMENTATION FAILED	(1) In the A position, the 12 electrical strip heaters receive 28v. In A/B position an additional 12 heaters receive 28v. (2) Normal operating temperature is +45 to +55°F. Redline is +27° and +100°F. (3) Double Heater operation is required for temperature control. (4) If A/B does not maintain temperature above 45°F, attitude constraints must be observed or SPS may become non-operational. SPS not operable if fuel temperature is <25°F
3 SPS PRPLNT TK-TEMP ind READING ABNORMAL	1 • SYS TEST sel (3) SA • USE SYS TEST ind for HEATER CONTROL → 2 MSFN CAN PROVIDE BACKUP BY MONITORING PRPLNT TEMP; IF TLM FUEL TEMP ABNORMAL → 3 MSFN must MONITOR OXID TEMP AND PROVIDE BACKUP TO CMDR FOR SPS-LINE HTRS SWITCH CONTROL	(1) Normal operating temperature is +45°F to +55°F. This is equivalent to 1.1–1.3 vdc on SYSTEM TEST ind. (2) SPS LINE HTRS sw ON at <45° and OFF when >55°F. Heaters must also be on if any OXID line temperatures is <20°F, and if any fuel line or valve body temperatures are <25°F.
4 NO RESPONSE OF OXID FLOW VLV TO DURING FLOW ADJUST (SPS QTY-OXID FLOW VLV-PRIM SW-PRIM)	1 • SPS QTY-OXID FLOW VLV-PRIM SW-SEC • SPS QTY-OXID FLOW VLV-INCR SW-INCR (DECR) FLOW VLV TO RESPONSE CORRECT → 2 PRIMARY OXID FLOW VALVE FAILED	(1) Switch position as required to adjust desired flow rate. Valve cannot be operated unless power is applied through THRUST ON Signal or through SPS QTY-TEST sw.

Basic Date _____ Change Date _____ Page _____

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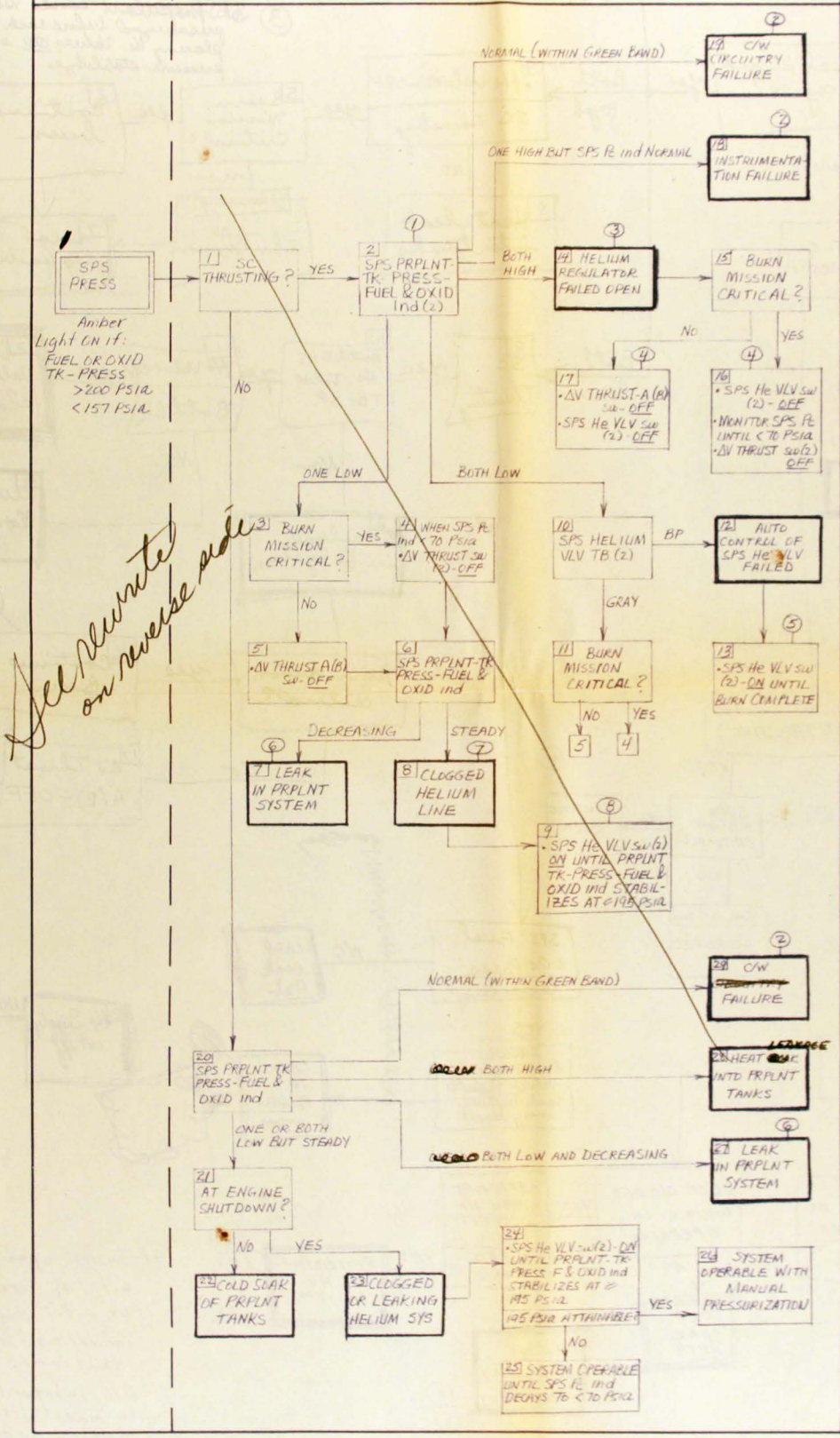
SYMPTOM
PROCEDURE
REMARKS
SPS PRESS
Amber Light ON if: FUEL OR OXID TK-PRESS >200 PSIA <157 PSIA
1 SC THRUSTING?
YES
NO
2 SPS PRPLNT TK PRESS-FUEL & OXID Ind (2)
NORMAL (WITHIN GREEN BAND)
19 C/W CIRCUITRY FAILURE
ONE HIGH BUT SPS Pc Ind NORMAL
18 INSTRUMENTATION FAILURE
BOTH HIGH
14 HELIUM REGULATOR FAILED OPEN
15 BURN MISSION CRITICAL?
NO
YES
17 • ΔV THRUST-A (2) SW - OFF • SPS He VLV SW (2) - OFF
16 • SPS He VLV SW (2) - OFF • MONITOR SPS Pc UNTIL < 70 PSIA • ΔV THRUST SW (2) OFF
ONE LOW
BOTH LOW
3 BURN MISSION CRITICAL?
YES
4 WHEN SPS Pc Ind < 70 PSIA • ΔV THRUST SW (2) - OFF
NO
5 • ΔV THRUST A (2) SW - OFF
6 SPS PRPLNT TK PRESS-FUEL & OXID Ind
10 SPS HELIUM VLV TB (2)
BP
12 AUTO CONTROL OF SPS He VLV FAILED
GRAY
11 BURN MISSION CRITICAL?
NO
YES
13 • SPS He VLV SW (2) - ON UNTIL BURN COMPLETE
DECREASING
STEADY
7 LEAK IN PRPLNT SYSTEM
8 CLOGGED HELIUM LINE
9 • SPS He VLV SW (2) ON UNTIL PRPLNT TK-PRESS-FUEL & OXID Ind STABILIZES AT @ 195 PSIA
28 C/W FAILURE
NORMAL (WITHIN GREEN BAND)
20 SPS PRPLNT TK PRESS-FUEL & OXID Ind
BOTH HIGH
29 HEAT LEAK INTO PRPLNT TANKS
ONE OR BOTH LOW BUT STEADY
BOTH LOW AND DECREASING
27 LEAK IN PRPLNT SYSTEM
21 AT ENGINE SHUTDOWN?
NO
YES
22 COLD SOAK OF PRPLNT TANKS
23 CLOGGED OR LEAKING HELIUM SYS
24 • SPS He VLV SW (2) ON UNTIL PRPLNT TK PRESS F & OXID Ind STABILIZES AT ≥ 195 PSIA
195 PSIA ATTAINABLE?
YES
NO
26 SYSTEM OPERABLE WITH MANUAL PRESSURIZATION
25 SYSTEM OPERABLE UNTIL SPS Pc Ind DECAYS TO < 70 PSIA
(1) Normal operating Pressure is 170 - 195 PSIA. MSFN will use FUEL & OXID telemetered Pressure data to backup onboard Pressure indications.
(2) SPS fully operable
(3) SPS Helium Valve Switches must remain OFF for duration of mission
(4) If ΔV THRUST switches are OFF Prior to SPS Pc indication of < 70 PSIA, more burns may be accomplished but SPS He VLV switches must remain OFF. ΔV THRUST switches OFF when SPS Pc indication decays to < 70 PSIA
(5) SPS operable with manual Pressurization during burns
(6) Further operation of SPS may be highly hazardous due to possibility of Propellant leakage.
(7) SPS operable per step 9
(8) Manually repressurize Prior to each burn.
G&N MALFUNCTION
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SPS MALFUNCTION
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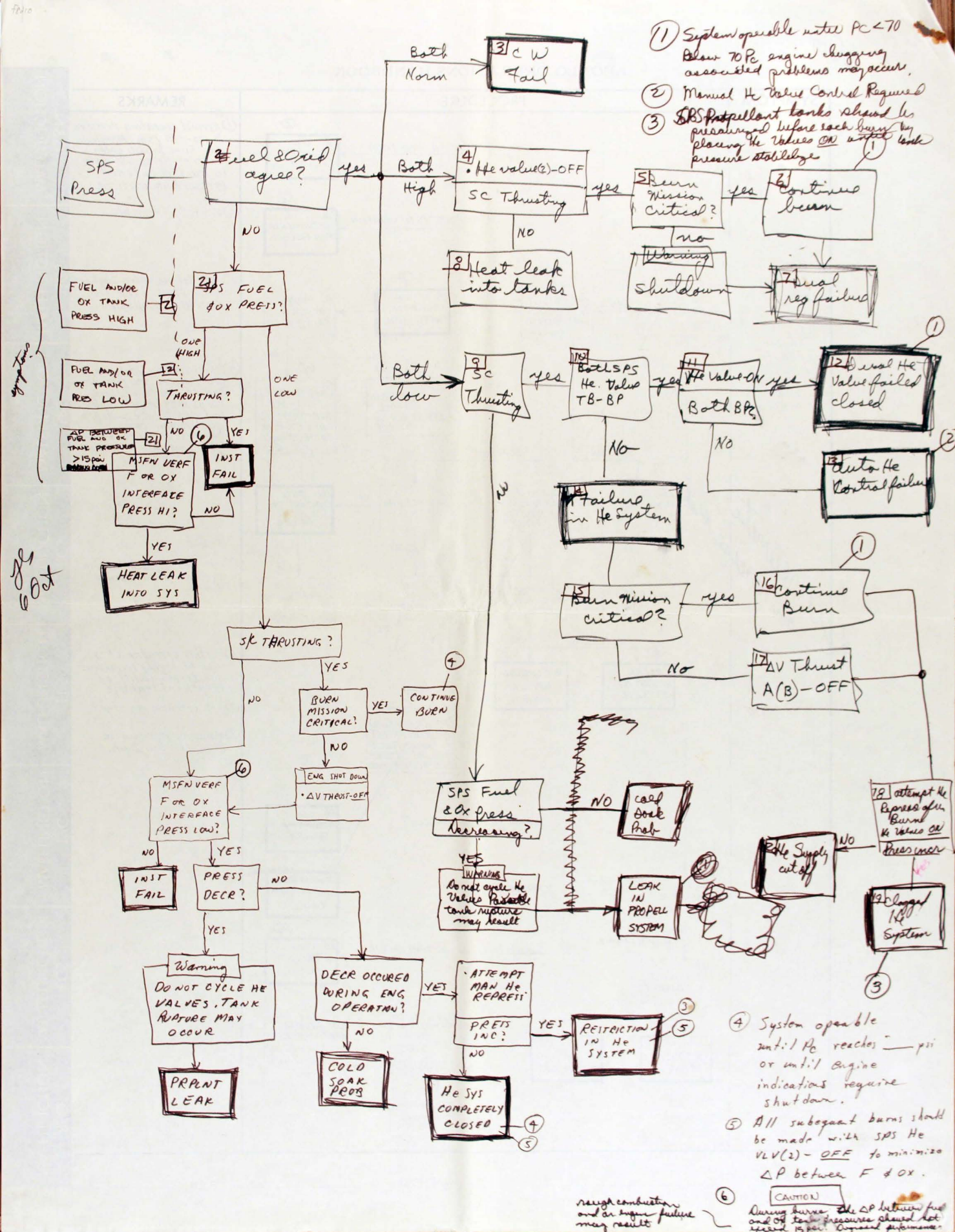
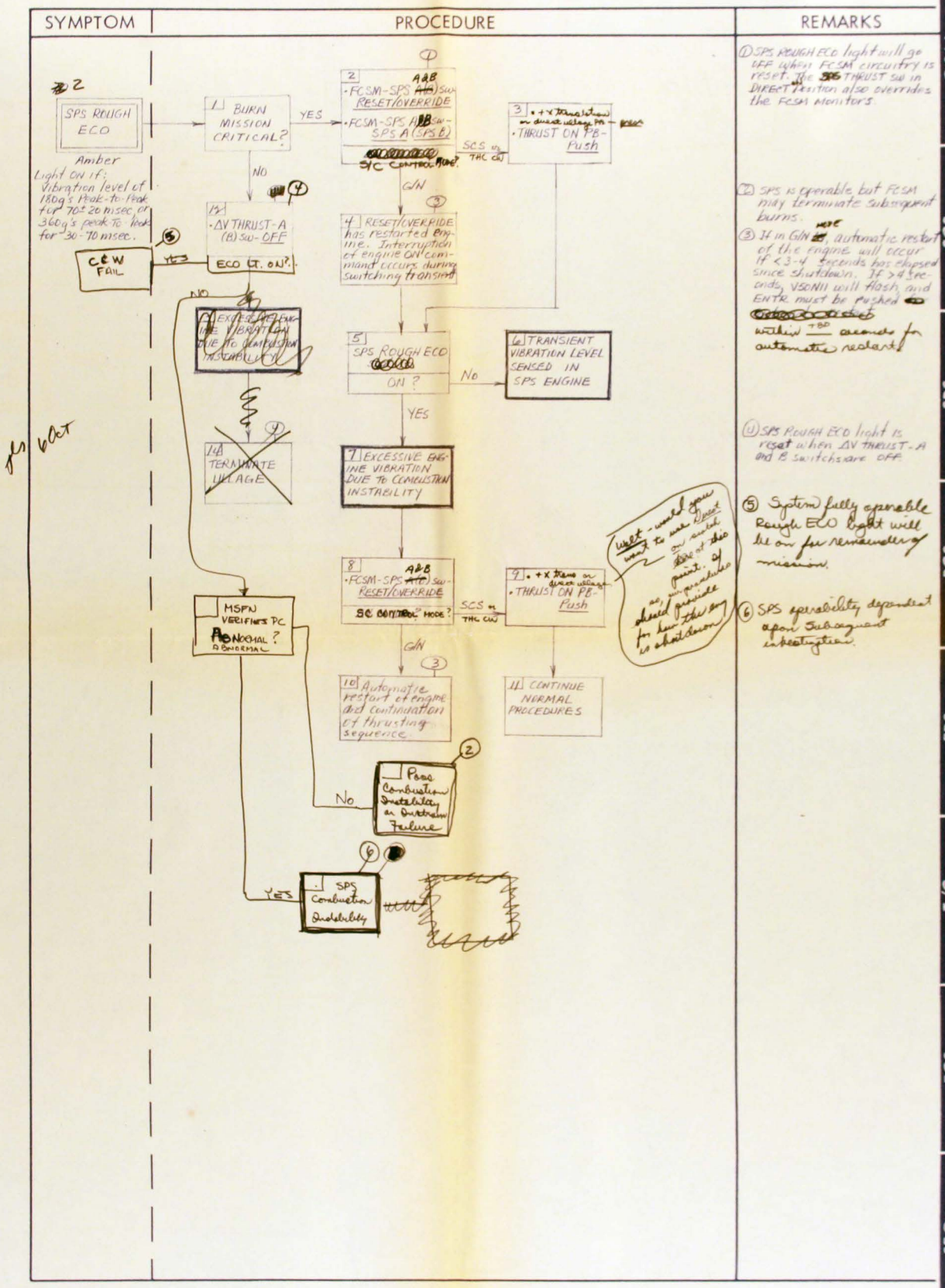

SPS Press
Fuel & Ox P agree?
yes
NO
Both Norm
3 C W Fail
Both High
4 • He valve(2)-OFF
SC Thrusting
yes
NO
5 Burn Mission critical?
yes
no
3 Continue burn
8 Heat leak into tanks
Warning
Shutdown
7 Dual reg failure
(1) System operable until Pc < 70
Below 70 Pc engine chugging associated problems may occur.
(2) Manual He Valve Control Required
(3) SPS Propellant tanks should be pressurized before each burn by placing the valves ON until tank pressure stabilizes
FUEL AND/OR OX TANK PRESS HIGH
2 SPS FUEL & OX PRESS?
ONE HIGH
FUEL AND/OR OX TANK PRES LOW
12
THRUSTING?
NO
YES
ONE LOW
ΔP BETWEEN FUEL AND OX TANK PRESSURE > 15 psi
21
6
INST FAIL
MSFN VERF F OR OX INTERFACE PRESS HI?
NO
YES
HEAT LEAK INTO SYS
Both low
9 SC Thrusting
yes
10 Both SPS He Valve TB-BP
yes
11 He Valve-OK
yes
Both BPs
12 Dual He Valve failed closed
NO
NO
13 Auto He Control failure
14 Failure in He System
SC THRUSTING?
YES
NO
BURN MISSION CRITICAL?
YES
4
CONTINUE BURN
NO
ENG SHUT DOWN
• ΔV THRUST-OFF
6
MSFN VERF F OR OX INTERFACE PRESS LOW?
NO
YES
INST FAIL
PRESS DECR?
NO
YES
Warning
DO NOT CYCLE HE VALVES, TANK RUPTURE MAY OCCUR
PRPLNT LEAK
DECR OCCURED DURING ENG OPERATN?
YES
NO
COLD SOAK PROB
• ATTEMPT MAN He REPRESS
PRESS INC?
YES
NO
RESTRICTION IN He SYSTEM
3
5
He SYS COMPLETELY CLOSED
4
5
SPS Fuel & Ox press decreasing?
NO
cold soak prob
YES
WARNING
Do not cycle He Valves Possible tank rupture may result
LEAK IN PROPEL SYSTEM
15 Burn Mission critical?
yes
16 Continue Burn
No
17 ΔV Thrust A(B)-OFF
18 attempt He Repress after Burn He Valves ON
Press incr
NO
He Supply cut off
19 Clogged He System
3
(4) System operable until Pc reaches ___ psi or until Engine indications require shutdown.
(5) All subsequent burns should be made with SPS He VLV(2) - OFF to minimize ΔP between F & Ox.
(6) CAUTION
During burns the ΔP between fuel and Ox tank pressures should not exceed 15 psi. Exceed performance
rough combustion and or engine failure may result



SYMPTOM	PROCEDURE	REMARKS
1 SPS FLANGE TEMP HI (YELLOW) Light on if: Injector/chamber flange temp is ≥ 480°F	1 BURN MISSION CRITICAL? YES → 2 CONTINUE BURN. NO → 3 IF THRUSTING ΔV THRUST-A (B) SW - OFF. MSFN FLANGE TEMP RESOLVES: BOTH NORMAL → CW FAILURE; 1 HIGH 1 NORMAL → 4 EXCESS FLANGE HEATING OR INSTRUMENTATION FAILURE; BOTH HIGH → EXCESSIVE FLANGE TEMP.	(1) Flange burn through may be expected at anytime, possibly resulting in chamber separation. ~~Maximum temperature should occur after shutdown.~~ (2) MSFN can confirm flange temperature over 480°F. ~~Loss of entire chamber. Visual check upon fitting of SPS.~~ ~~(3) SPS MAY BE USABLE FOR CRITICAL BURN.~~
2 PROPLNT HTRS FAIL TO RAISE PROPLNT TEMPERATURE	1 SPS-LINE HTRS sw A/B; SPS PROPLNT TK-TEMP ind; TEMP INCREASES? YES → 2 SYSTEM A HEATING INSUFFICIENT OR FAILED OFF. NO → 3 DUAL HTRS SYS FAILED, SWITCH, OR INSTRUMENTATION FAILED	(1) In the A position, the 12 electrical strip heaters receive 28v, in A/B position an additional 12 heaters receive 28v. (2) Normal operating temperature is +45 to +55°F. Redline is +27° and +100°F. (3) Double Heater operation is required for temperature control. (4) If A/B does not maintain temperature above 45°F attitude constraints must be observed or SPS may become non-operational. SPS not operable if fuel temperature is <25°F
3 SPS PROPLNT TK-TEMP ind READING ABNORMAL	1 SYS TEST sel (6) SA; USE SYS TEST ind for HEATER CONTROL. 2 MSFN CAN PROVIDE BACKUP BY MONITORING PROPLNT TEMP. IF TLM FUEL TEMP ABNORMAL → 3 MSFN must MONITOR OXID TEMP AND PROVIDE BACKUP TO CREW FOR SPS-LINE HTRS SWITCH CONTROL	(1) Normal operating temperature is +45° to +55°F. This is equivalent to 1.1–1.3 vdc on SYSTEM TEST ind. (2) SPS LINE HTRS sw ON at <45° and OFF when >55°F. Heaters must also be ON if any OXID line temperatures is <20°F, and if any fuel line or valve body temperatures are <25°F.
4 NO RESPONSE OF OXID FLOW VLV TB DURING FLOW ADJUST (SPS QTY-OXID FLOW VLV-PRIM sw - PRIM)	1 SPS QTY-OXID FLOW VLV-PRIM SW - SEC; SPS QTY-OXID FLOW VLV-INCR SW - INCR (DECR). FLOW VLV TB RESPONSE CORRECT → 2 PRIMARY OXID FLOW VALVE FAILED. PRIMARY AND SEC OXID FLOW VLVS FAILED	(1) Switch position as required to adjust desired flow rate. Valve cannot be operated unless power is applied through THRUST ON signal or through SPS QTY-TEST sw. (2) Secondary valve has sufficient range to compensate for primary valve failure in any position and still provide valve openings for INCREASE, NORMAL or DECREASE OXID flow.

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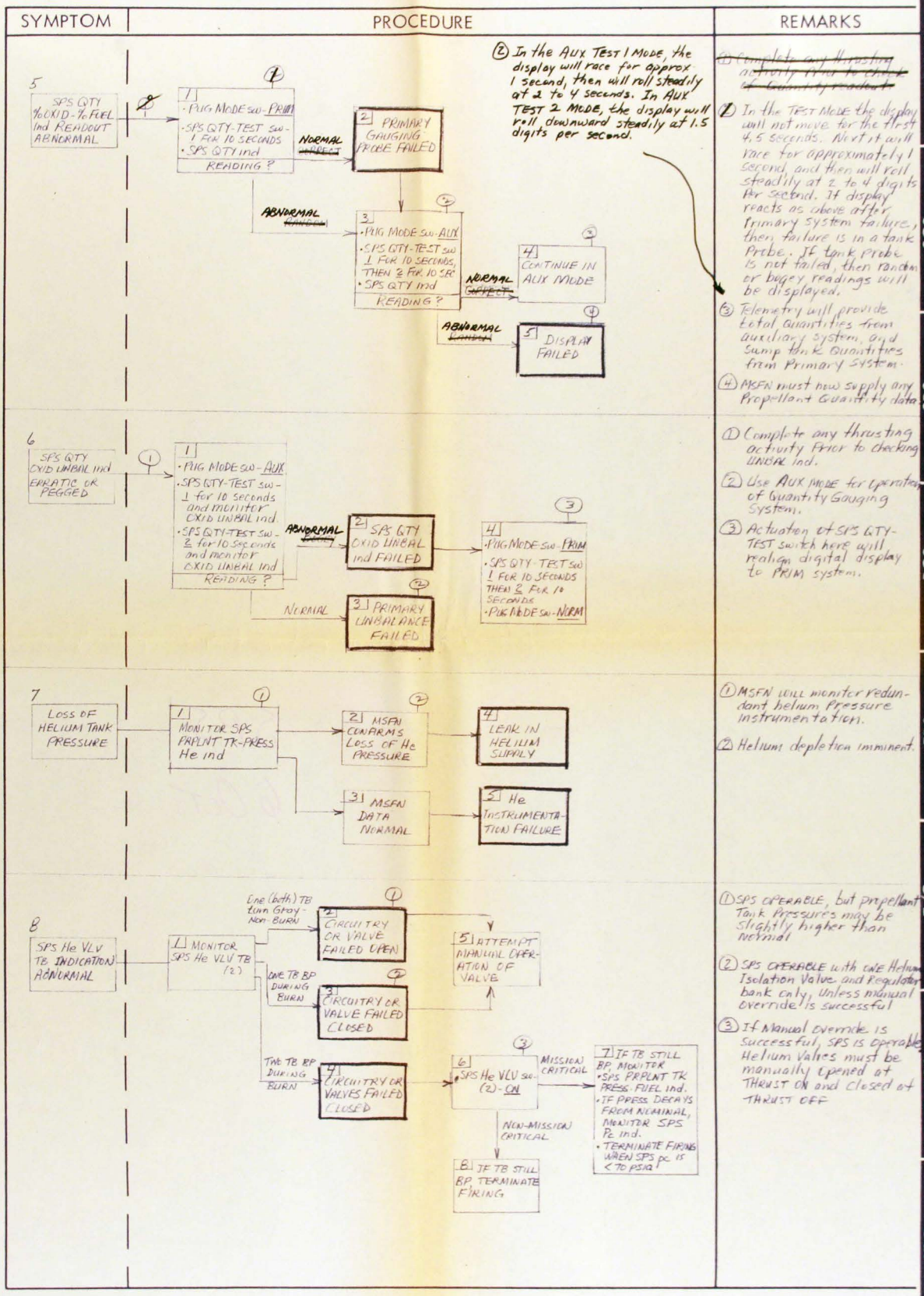

SPS
6 Oct